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Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

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Listing of Claims:

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1. (Cancelled)

2. (Cancelled)

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3. (Currently Amended) ~~An apparatus for blind separation of an overcomplete set of mixed signals as set forth in claim 2,~~ An apparatus for blind separation of an overcomplete set of mixed signals, the apparatus comprising:

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i. a data processing system including an input for receiving mixed signals from a plurality of sensors configured to receive mixed signal samples comprising a mixture of signals transmitted from signal sources through an environment and noise, a signal processor attached with the input for receiving the mixed signals from the sensors, and a memory for storing data during operations of the signal processor; the data processing system further comprising:

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ii. means for storing data representing the input from the sensors in a mixed signal matrix \mathbf{X} ;

iii. means for storing data representing the noise in a noise matrix \mathbf{V} ;

iv. means for storing data representing an estimate of the individual signals from the mixture of signals from the signal sources in a source signal estimate matrix $\hat{\mathbf{S}}$;

- 5 v. means for storing data representing an estimate of the effects of the environment in a estimated mixing matrix \hat{A} where the matrices are related by $X = \hat{A}\hat{S} + V$;
- vi. means for generating an initial estimate of the estimated mixing matrix \hat{A} ;
- vii. means for determining the number of signal sources and associated lines of
10 correlation of each of the signal sources from the estimated mixing matrix \hat{A} , and for representing the signal sources in the source signal estimate matrix \hat{S} ;
- viii. means for jointly optimizing the source signal estimate matrix \hat{S} and the estimated mixing matrix \hat{A} in an iterative manner, to generate an optimized
15 source signal estimate matrix \hat{S} and a final estimated mixing matrix \hat{A} ; and
- ix. means for restoring the separated source signals from the optimized source signal estimate matrix \hat{S} , whereby a plurality of mixed signals from unknown sources traveling through an environment with added noise may be separated so that the original, separate signals may be reconstructed,
20 wherein the means for generating an initial estimate of the estimated mixing matrix \hat{A} comprises:
- i. means for transforming the mixed signal matrix X into the sparse domain using a transform operator;
- ii. means for determining a frequency band within the sparse domain that
25 contains the most information that can be used to determine lines of correlation to determine the number of signal sources;
- iii. means for determining a measure and an optimal threshold for the measure for the determination of noise within the frequency band;
- iv. means for recalculating the measure used in the determination of the noise within the frequency band using the optimal threshold; and
30 and
- v. means for determining the local maxima of a distribution of the measure, where the local maxima represent angles which are inserted

5 into the estimated mixing matrix \hat{A} to provide an initial estimate of
 the estimated mixing matrix \hat{A} ;

 wherein the means for jointly optimizing the source signal estimate matrix \hat{S} and
 the estimated mixing matrix \hat{A} in an iterative manner, to generate an optimized
 source signal estimate matrix \hat{S} and a final estimated mixing matrix \hat{A}
10 comprises:

- i. means for clustering the mixed signal samples using a geometric
 constraint; and
- ii. means for evaluating a convergence criteria based on the clustered
 mixed signal samples to determine whether the convergence criteria
15 are met, and if the convergence criteria are not met, iteratively
 adjusting the clustering of the mixed signal samples and parameters of
 the geometric constraint to create a new set of clusters until the
 convergence criteria are met, to provide a final estimated mixing
 matrix \hat{A} .

20 4. (Cancelled)

5. (Currently Amended) ~~An apparatus for blind separation of an overcomplete set of~~
 ~~mixed signals as set forth in claim 2~~ An apparatus for blind separation of an
25 overcomplete set of mixed signals, the apparatus comprising:

- i. a data processing system including an input for receiving mixed signals
 from a plurality of sensors configured to receive mixed signal samples
 comprising a mixture of signals transmitted from signal sources through an
 environment and noise, a signal processor attached with the input for
30 receiving the mixed signals from the sensors, and a memory for storing data
 during operations of the signal processor; the data processing system further
 comprising:

- 5 ii. means for storing data representing the input from the sensors in a mixed signal matrix \mathbf{X} ;
- iii. means for storing data representing the noise in a noise matrix \mathbf{V} ;
- iv. means for storing data representing an estimate of the individual signals from the mixture of signals from the signal sources in a source signal
- 10 estimate matrix $\hat{\mathbf{S}}$;
- v. means for storing data representing an estimate of the effects of the environment in a estimated mixing matrix $\hat{\mathbf{A}}$ where the matrices are related by $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$;
- vi. means for generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$;
- 15 vii. means for determining the number of signal sources and associated lines of correlation of each of the signal sources from the estimated mixing matrix $\hat{\mathbf{A}}$, and for representing the signal sources in the source signal estimate matrix $\hat{\mathbf{S}}$;
- viii. means for jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the
- 20 estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$; and
- ix. means for restoring the separated source signals from the optimized source signal estimate matrix $\hat{\mathbf{S}}$, whereby a plurality of mixed signals from unknown sources traveling through an environment with added noise may
- 25 be separated so that the original, separate signals may be reconstructed;
- wherein the means for generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$ comprises:
- i. means for transforming the mixed signal matrix \mathbf{X} into the sparse domain using a transform operator;
- 30 ii. means for determining a frequency band within the sparse domain that contains the most information that can be used to determine lines of correlation to determine the number of signal sources;

- 5 iii. means for determining a measure and an optimal threshold for the measure
 for the determination of noise within the frequency band;
- iv. means for recalculating the measure used in the determination of the noise
 within the frequency band using the optimal threshold; and
- 10 v. means for determining the local maxima of a distribution of the measure,
 where the local maxima represent angles which are inserted into the
 estimated mixing matrix $\hat{\mathbf{A}}$ to provide an initial estimate of the estimated
 mixing matrix $\hat{\mathbf{A}}$;

 wherein the means for jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$
 and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an
15 optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$
 further comprises:

- i. means for obtaining a multi-band sparse domain estimate of the source
 signal estimate matrix $\hat{\mathbf{S}}$ using the relationship $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$; and
- ii. means for using the adjusted geometric constraint corresponding to the
20 final estimated mixing matrix $\hat{\mathbf{A}}$ in each of the bands of the sparse
 domain for the source signal estimate matrix $\hat{\mathbf{S}}$ and determining whether
 a convergence criteria is met for the source signal estimate matrix $\hat{\mathbf{S}}$,
 and if the convergence criteria are not met, iteratively adjusting the
 clustering of the mixed signal samples to create a new set of clusters
25 until the convergence criteria are met, to provide a final source signal
 estimate matrix $\hat{\mathbf{S}}$.

6. (Cancelled)

- 30 7. (Currently Amended) An apparatus for blind separation of an overcomplete set of
 mixed signals as set forth in claim 3 +, wherein the means for generating an initial
 estimate of the estimated mixing matrix $\hat{\mathbf{A}}$ comprises:

- 5 i. means for transforming the mixed signal matrix \mathbf{X} into the frequency domain using a Fourier operator;
- ii. means for using a mutual information criterion to determine a frequency band within the sparse domain that contains the most information that can be used to determine lines of correlation to determine the number of signal sources;
- 10 iii. means for determining a random variable $ang = \arctan \frac{x_i(band)}{x_j(band)}$, where $x_i(band)$ and $x_j(band)$ represent Fourier values of mixture in the selected frequency band, and an optimal threshold ANG for ang , where the optimal threshold ANG is determined by computing the entropy $E(ang, ANG)$ vs. ANG and searching for the optimal value of ANG corresponding to the
- 15 minimum rate of descent of the entropy $E(ang, ANG)$;
- iv. means for recalculating ang based on the optimal threshold ANG;
- v. means for using a standard peak detection technique to determine the number and values of local maxima of a histogram of ang where the local maxima represent angles which are inserted into the estimated mixing matrix $\hat{\mathbf{A}}$ to
- 20 provide an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$.
8. (Original) An apparatus for blind separation of an overcomplete set of mixed signals as set forth in claim 7, wherein the means for jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to
- 25 generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$ comprises:
- i. means for clustering the mixed signal samples in the Fourier domain along the lines of correlation with one cluster per source using a straight distance metric geometric constraint, with the clusters representing estimates of the Fourier
- 30 domain representation of $\hat{\mathbf{S}}$, $\mathbf{F}(\hat{\mathbf{S}})$, where \mathbf{F} represents a Fourier domain operator ; and

5 ii. means for evaluating a convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, with the
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, developed from the log likelihood function
 $\mathbf{L}(\mathbf{F}(\hat{\mathbf{S}}) | \mathbf{F}(\mathbf{X}), \mathbf{A})$ with the assumption of Laplanicity of source signals in the
Fourier domain following the probability $\mathbf{P}(\mathbf{F}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|}$, where
 $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit vector, with the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$,
10 evaluated based on the clustered mixed signal samples to determine whether the
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, and if the convergence criteria, \min
 $\lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is not met, iteratively adjusting the clustering of the mixed signal
samples and parameters of the geometric constraint to create a new set of
clusters until the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, to provide a final
15 estimated mixing matrix $\hat{\mathbf{A}}$.

9. (Original) An apparatus for blind separation of an overcomplete set of mixed signals
as set forth in claim 8, wherein the means for jointly optimizing the source signal
estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to
20 generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing
matrix $\hat{\mathbf{A}}$ further comprises:

i. means for obtaining a multi-band sparse domain estimate of the source signal
estimate matrix $\hat{\mathbf{S}}$ using the relationship $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$, applied in the Wavelet
domain; and
25 ii. means for using the adjusted geometric constraint corresponding to the final
estimated mixing matrix $\hat{\mathbf{A}}$ in each of the bands of the Wavelet domain for the
source signal estimate matrix $\hat{\mathbf{S}}$, $\mathbf{W}(\hat{\mathbf{S}})$, and determining whether a
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$ is met for the source signal estimate

5 matrix \hat{S} , where the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{S})|$, is developed from
the log likelihood function $L(\mathbf{W}(\hat{S}) | \mathbf{W}(\mathbf{X}), \mathbf{A})$ with the assumption of
Laplancity of source signals in the Wavelet domain following the probability
 $P(\mathbf{W}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{W}(\hat{S})|}$, where $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit vector, and if the
convergence criteria is not met, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{S})|$, iteratively adjusting the
10 clustering of the mixed signal samples to create a new set of clusters until the
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{S})|$, is met, to provide a final source signal
estimate matrix \hat{S} .

10. (Original) An apparatus for blind separation of an overcomplete set of mixed signals
15 as set forth in claim 9, wherein the apparatus is configured for separating mixed
acoustic signals.

11. (Original) An apparatus for blind separation of an overcomplete set of mixed signals
as set forth in claim 9, wherein the apparatus is configured for separating mixed radio
20 frequency signals.

12. (Cancelled)

13. (Cancelled)

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14. (Currently Amended) ~~A method for blind separation of an overcomplete set of mixed
signals as set forth in claim 13~~ A method for blind separation of an overcomplete set
of mixed signals, using a data processing system including an input for receiving
mixed signals from a plurality of sensors configured to receive mixed signal samples
30 comprising a mixture of signals transmitted from signal sources through an
environment and noise, a signal processor attached with the input for receiving the

- 5 mixed signals from the sensors, and a memory for storing data during operations of the signal processor the method comprising the steps of:
- i. storing data representing the input from the sensors in a mixed signal matrix \mathbf{X} ;
 - ii. storing data representing the noise in a noise matrix \mathbf{V} ;
 - 10 iii. storing data representing an estimate of the individual signals from the mixture of signals from the signal sources in a source signal estimate matrix $\hat{\mathbf{S}}$;
 - iv. storing data representing an estimate of the effects of the environment in a estimated mixing matrix $\hat{\mathbf{A}}$ where the matrices are related by $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$;
 - 15 v. generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$;
 - vi. determining the number of signal sources and associated lines of correlation of each of the signal sources from the estimated mixing matrix $\hat{\mathbf{A}}$, and for representing the signal sources in the source signal estimate matrix $\hat{\mathbf{S}}$;
 - vii. jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated
 - 20 mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$; and
 - viii. restoring the separated source signals from the optimized source signal estimate matrix $\hat{\mathbf{S}}$, whereby a plurality of mixed signals from unknown
 - 25 sources traveling through an environment with added noise may be separated so that the original, separate signals may be reconstructed;
 - wherein the step of generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$ comprises the sub-steps of:
 - i. transforming the mixed signal matrix \mathbf{X} into the sparse domain using a transform operator;
 - 30 ii. determining a frequency band within the sparse domain that contains the most information that can be used to determine lines of correlation to determine the number of signal sources;

- 5 iii. determining a measure and an optimal threshold for the measure for the
 determination of noise within the frequency band;
 iv. recalculating the measure used in the determination of the noise within the
 frequency band using the optimal threshold; and
 v. determining the local maxima of a distribution of the measure, where the
10 local maxima represent angles which are inserted into the estimated mixing
 matrix \hat{A} to provide an initial estimate of the estimated mixing matrix \hat{A} ,
 and

 wherein the step of jointly optimizing the source signal estimate matrix \hat{S} and the
 estimated mixing matrix \hat{A} in an iterative manner, to generate an optimized source
15 signal estimate matrix \hat{S} and a final estimated mixing matrix \hat{A} comprises the sub-
 steps of:

- i. clustering the mixed signal samples using a geometric constraint; and
 ii. evaluating a convergence criteria based on the clustered mixed signal
 samples to determine whether the convergence criteria are met, and if
20 the convergence criteria are not met, iteratively adjusting the clustering
 of the mixed signal samples and parameters of the geometric constraint
 to create a new set of clusters until the convergence criteria are met, to
 provide a final estimated mixing matrix \hat{A} .

25 15. (Cancelled)

16. (Currently Amended) ~~A method for blind separation of an overcomplete set of mixed~~
 ~~signals as set forth in claim 13~~ A method for blind separation of an overcomplete set
 of mixed signals, using a data processing system including an input for receiving
30 mixed signals from a plurality of sensors configured to receive mixed signal samples
 comprising a mixture of signals transmitted from signal sources through an
 environment and noise, a signal processor attached with the input for receiving the
 mixed signals from the sensors, and a memory for storing data during operations of
 the signal processor the method comprising the steps of:

- 5 i. storing data representing the input from the sensors in a mixed signal matrix \mathbf{X} ;
- ii. storing data representing the noise in a noise matrix \mathbf{V} ;
- iii. storing data representing an estimate of the individual signals from the mixture of signals from the signal sources in a source signal estimate matrix $\hat{\mathbf{S}}$;
- 10 iv. storing data representing an estimate of the effects of the environment in a estimated mixing matrix $\hat{\mathbf{A}}$ where the matrices are related by $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$;
- v. generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$;
- vi. determining the number of signal sources and associated lines of correlation of each of the signal sources from the estimated mixing matrix $\hat{\mathbf{A}}$, and for representing the signal sources in the source signal estimate matrix $\hat{\mathbf{S}}$;
- 15 vii. jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$; and
- 20 viii. restoring the separated source signals from the optimized source signal estimate matrix $\hat{\mathbf{S}}$, whereby a plurality of mixed signals from unknown sources traveling through an environment with added noise may be separated so that the original, separate signals may be reconstructed;
- wherein the step of generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$ comprises the sub-steps of:
- 25 i. transforming the mixed signal matrix \mathbf{X} into the sparse domain using a transform operator;
- ii. determining a frequency band within the sparse domain that contains the most information that can be used to determine lines of correlation to
- 30 determine the number of signal sources;
- iii. determining a measure and an optimal threshold for the measure for the determination of noise within the frequency band;

- 5 iv. recalculating the measure used in the determination of the noise within the
 frequency band using the optimal threshold; and
 v. determining the local maxima of a distribution of the measure, where the
 local maxima represent angles which are inserted into the estimated
 mixing matrix $\hat{\mathbf{A}}$ to provide an initial estimate of the estimated mixing
10 matrix $\hat{\mathbf{A}}$, and

wherein the wherein the step of jointly optimizing the source signal estimate
matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to
generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated
mixing matrix $\hat{\mathbf{A}}$ further comprises the sub steps of:

- 15 i. obtaining a multi-band sparse domain estimate of the source signal
 estimate matrix $\hat{\mathbf{S}}$ using the relationship $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$; and
 ii. using the adjusted geometric constraint corresponding to the final
 estimated mixing matrix $\hat{\mathbf{A}}$ in each of the bands of the sparse domain
 for the source signal estimate matrix $\hat{\mathbf{S}}$ and determining whether a
20 convergence criteria is met for the source signal estimate matrix $\hat{\mathbf{S}}$, and
 if the convergence criteria are not met, iteratively adjusting the
 clustering of the mixed signal samples to create a new set of clusters
 until the convergence criteria are met, to provide a final source signal
 estimate matrix $\hat{\mathbf{S}}$.

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17. (Cancelled)

18. (Currently Amended) A method for blind separation of an overcomplete set of mixed
signals as set forth in claim 14 12, wherein the step of generating an initial estimate of
30 the estimated mixing matrix $\hat{\mathbf{A}}$ comprises the sub steps of:
 i. transforming the mixed signal matrix \mathbf{X} into the frequency domain using a
 Fourier operator;

- 5 ii. using a mutual information criterion to determine a frequency band within the
sparse domain that contains the most information that can be used to
determine lines of correlation to determine the number of signal sources;
- iii. determining a random variable $ang = \arctan \frac{x_i(band)}{x_j(band)}$, where $x_i(band)$ and
 $x_j(band)$ represent Fourier values of mixture in the selected frequency band,
10 and an optimal threshold ANG for ang , where the optimal threshold ANG is
determined by computing the entropy $E(ang, ANG)$ vs. ANG and searching
for the optimal value of ANG corresponding to the minimum rate of descent
of the entropy $E(ang, ANG)$;
- iv. recalculating ang based on the optimal threshold ANG;
- 15 v. using a standard peak detection technique to determine the number and values
of local maxima of a histogram of ang where the local maxima represent
angles which are inserted into the estimated mixing matrix $\hat{\mathbf{A}}$ to provide an
initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$.
- 20 19. (Original) A method for blind separation of an overcomplete set of mixed signals as
set forth in claim 18, wherein the step of jointly optimizing the source signal estimate
matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an
optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$
comprises the sub steps of:
- 25 i. clustering the mixed signal samples in the Fourier domain along the lines of
correlation with one cluster per source using a straight distance metric
geometric constraint, with the clusters representing estimates of the Fourier
domain representation of $\hat{\mathbf{S}}$, $\mathbf{F}(\hat{\mathbf{S}})$, where \mathbf{F} represents a Fourier domain
operator ; and
- 30 ii. evaluating a convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, with the convergence criteria,
 $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, developed from the log likelihood function $\mathbf{L}(\mathbf{F}(\hat{\mathbf{S}}) | \mathbf{F}(\mathbf{X}), \mathbf{A})$
with the assumption of Laplanicity of source signals in the Fourier domain

5 following the probability $P(\mathbf{F}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|}$, where $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit
vector, with the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, evaluated based on the
clustered mixed signal samples to determine whether the convergence criteria,
 $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, and if the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is not
met, iteratively adjusting the clustering of the mixed signal samples and
10 parameters of the geometric constraint to create a new set of clusters until the
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, to provide a final estimated mixing
matrix $\hat{\mathbf{A}}$.

20. (Original) A method for blind separation of an overcomplete set of mixed signals as
15 set forth in claim 19, wherein the wherein the step of jointly optimizing the source
signal estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner,
to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated
mixing matrix $\hat{\mathbf{A}}$ further comprises the sub steps of:

- i. obtaining a multi-band sparse domain estimate of the source signal estimate
20 matrix $\hat{\mathbf{S}}$ using the relationship $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$, applied in the Wavelet domain;
and
- ii. using the adjusted geometric constraint corresponding to the final estimated
mixing matrix $\hat{\mathbf{A}}$ in each of the bands of the Wavelet domain for the source
signal estimate matrix $\hat{\mathbf{S}}$, $\mathbf{W}(\hat{\mathbf{S}})$, and determining whether a convergence
25 criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$ is met for the source signal estimate matrix $\hat{\mathbf{S}}$, where
the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, is developed from the log likelihood
function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A})$ with the assumption of Laplanicity of source
signals in the Wavelet domain following the probability $P(\mathbf{W}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|}$,
where $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit vector, and if the convergence criteria is not met,

5 $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, iteratively adjusting the clustering of the mixed signal samples
to create a new set of clusters until the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, is
met, to provide a final source signal estimate matrix $\hat{\mathbf{S}}$.

10 21. (Original) A method for blind separation of an overcomplete set of mixed signals as
set forth in claim 20, wherein the method is configured to separate mixed acoustic
signals.

15 22. (Original) A method for blind separation of an overcomplete set of mixed signals as
set forth in claim 20, wherein the method is configured to separate mixed radio
frequency signals.

23. (Cancelled)

20 24. (Cancelled)

25 25. (Currently Amended) ~~A computer program product for blind separation of an
overcomplete set of mixed signals as set forth in claim 24~~ A computer program
product for blind separation of an overcomplete set of mixed signals, readable on a
data processing system including an input for receiving mixed signals from a plurality
of sensors configured to receive mixed signal samples comprising a mixture of
signals transmitted from signal sources through an environment and noise, a signal
processor attached with the input for receiving the mixed signals from the sensors,
and a memory for storing data during operations of the signal processor the computer
program product comprising means, stored on a computer readable medium, for:
30 i. storing data representing the input from the sensors in a mixed signal matrix
 \mathbf{X} ;
 ii. storing data representing the noise in a noise matrix \mathbf{V} ;

- 5 iii. storing data representing an estimate of the individual signals from the mixture of signals from the signal sources in a source signal estimate matrix $\hat{\mathbf{S}}$;
- iv. storing data representing an estimate of the effects of the environment in a estimated mixing matrix $\hat{\mathbf{A}}$ where the matrices are related by $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$;
- 10 v. generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$;
- vi. determining the number of signal sources and associated lines of correlation of each of the signal sources from the estimated mixing matrix $\hat{\mathbf{A}}$, and for representing the signal sources in the source signal estimate matrix $\hat{\mathbf{S}}$;
- vii. jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated
- 15 mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$; and
- viii. restoring the separated source signals from the optimized source signal estimate matrix $\hat{\mathbf{S}}$, whereby a plurality of mixed signals from unknown
- sources traveling through an environment with added noise may be
- 20 separated so that the original, separate signals may be reconstructed,
- wherein the means for generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$ comprises:
- i. means for transforming the mixed signal matrix \mathbf{X} into the sparse domain using a transform operator;
- 25 ii. means for determining a frequency band within the sparse domain that contains the most information that can be used to determine lines of correlation to determine the number of signal sources;
- iii. means for determining a measure and an optimal threshold for the measure for the determination of noise within the frequency band;
- 30 iv. means for recalculating the measure used in the determination of the noise within the frequency band using the optimal threshold; and

5. v. means for determining the local maxima of a distribution of the measure,
where the local maxima represent angles which are inserted into the
estimated mixing matrix $\hat{\mathbf{A}}$ to provide an initial estimate of the estimated
mixing matrix $\hat{\mathbf{A}}$, and

wherein the means for jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the
10 estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an optimized source
signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$ comprises:

- i. means for clustering the mixed signal samples using a geometric constraint; and
- ii. means for evaluating a convergence criteria based on the clustered mixed signal
15 samples to determine whether the convergence criteria are met, and if the
convergence criteria are not met, iteratively adjusting the clustering of the
mixed signal samples and parameters of the geometric constraint to create a new
set of clusters until the convergence criteria are met, to provide a final estimated
mixing matrix $\hat{\mathbf{A}}$.

20 26. (Cancelled)

27. (Currently Amended) ~~A computer program product for blind separation of an~~
~~overcomplete set of mixed signals as set forth in claim 24, A computer program~~
25 product for blind separation of an overcomplete set of mixed signals, readable on a
data processing system including an input for receiving mixed signals from a plurality
of sensors configured to receive mixed signal samples comprising a mixture of
signals transmitted from signal sources through an environment and noise, a signal
processor attached with the input for receiving the mixed signals from the sensors,
and a memory for storing data during operations of the signal processor the computer
30 program product comprising means, stored on a computer readable medium, for:

- i. storing data representing the input from the sensors in a mixed signal matrix
 \mathbf{X} ;
- ii. storing data representing the noise in a noise matrix \mathbf{V} ;

- 5 iii. storing data representing an estimate of the individual signals from the mixture of signals from the signal sources in a source signal estimate matrix $\hat{\mathbf{S}}$;
- iv. storing data representing an estimate of the effects of the environment in a estimated mixing matrix $\hat{\mathbf{A}}$ where the matrices are related by $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$;
- 10 v. generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$;
- vi. determining the number of signal sources and associated lines of correlation of each of the signal sources from the estimated mixing matrix $\hat{\mathbf{A}}$, and for representing the signal sources in the source signal estimate matrix $\hat{\mathbf{S}}$;
- vii. jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$; and
- 15 viii. restoring the separated source signals from the optimized source signal estimate matrix $\hat{\mathbf{S}}$, whereby a plurality of mixed signals from unknown sources traveling through an environment with added noise may be
- 20 separated so that the original, separate signals may be reconstructed,
wherein the means for generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$ comprises:
- i. means for transforming the mixed signal matrix \mathbf{X} into the sparse domain using a transform operator;
- 25 ii. means for determining a frequency band within the sparse domain that contains the most information that can be used to determine lines of correlation to determine the number of signal sources;
- iii. means for determining a measure and an optimal threshold for the measure for the determination of noise within the frequency band;
- 30 iv. means for recalculating the measure used in the determination of the noise within the frequency band using the optimal threshold; and

- 5 v. means for determining the local maxima of a distribution of the
measure, where the local maxima represent angles which are inserted
into the estimated mixing matrix $\hat{\mathbf{A}}$ to provide an initial estimate of
the estimated mixing matrix $\hat{\mathbf{A}}$, and

wherein the wherein the means for jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$
10 and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an optimized
source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$ further
comprises:

- i. means for obtaining a multi-band sparse domain estimate of the source signal
estimate matrix $\hat{\mathbf{S}}$ using the relationship $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$; and
15 ii. means for using the adjusted geometric constraint corresponding to the final
estimated mixing matrix $\hat{\mathbf{A}}$ in each of the bands of the sparse domain for the
source signal estimate matrix $\hat{\mathbf{S}}$ and determining whether a convergence criteria
is met for the source signal estimate matrix $\hat{\mathbf{S}}$, and if the convergence criteria
are not met, iteratively adjusting the clustering of the mixed signal samples to
20 create a new set of clusters until the convergence criteria are met, to provide a
final source signal estimate matrix $\hat{\mathbf{S}}$.

28. (Cancelled)

- 25 29. (Currently Amended) A computer program product for blind separation of an
overcomplete set of mixed signals as set forth in claim 25 23, wherein the means for
generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$ comprises:
i. means for transforming the mixed signal matrix \mathbf{X} into the frequency domain
using a Fourier operator;
30 ii. means for using a mutual information criterion to determine a frequency band
within the sparse domain that contains the most information that can be used
to determine lines of correlation to determine the number of signal sources;

- 5 iii. means for determining a random variable $ang = \arctan \frac{x_i(band)}{x_j(band)}$, where
- $x_i(band)$ and $x_j(band)$ represent Fourier values of mixture in the selected frequency band, and an optimal threshold ANG for ang , where the optimal threshold ANG is determined by computing the entropy $E(ang, ANG)$ vs. ANG and searching for the optimal value of ANG corresponding to the
- 10 minimum rate of descent of the entropy $E(ang, ANG)$;
- iv. means for recalculating ang based on the optimal threshold ANG;
- v. means for using a standard peak detection technique to determine the number and values of local maxima of a histogram of ang where the local maxima represent angles which are inserted into the estimated mixing matrix $\hat{\mathbf{A}}$ to
- 15 provide an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$.
30. (Original) A computer program product for blind separation of an overcomplete set of mixed signals as set forth in claim 29, wherein the means for jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative
- 20 manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$ comprises:
- i. means for clustering the mixed signal samples in the Fourier domain along the lines of correlation with one cluster per source using a straight distance metric geometric constraint, with the clusters representing estimates of the Fourier
- 25 domain representation of $\hat{\mathbf{S}}$, $\mathbf{F}(\hat{\mathbf{S}})$, where \mathbf{F} represents a Fourier domain operator ; and
- ii. means for evaluating a convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, with the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, developed from the log likelihood function $\mathbf{L}(\mathbf{F}(\hat{\mathbf{S}}) | \mathbf{F}(\mathbf{X}), \mathbf{A})$ with the assumption of Laplanicity of source signals in the
- 30 Fourier domain following the probability $\mathbf{P}(\mathbf{F}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|}$, where

5 $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit vector, with the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$,
evaluated based on the clustered mixed signal samples to determine whether the
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, and if the convergence criteria, \min
 $\lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is not met, iteratively adjusting the clustering of the mixed signal
samples and parameters of the geometric constraint to create a new set of
10 clusters until the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, to provide a final
estimated mixing matrix $\hat{\mathbf{A}}$.

31. (Original) A computer program product for blind separation of an overcomplete set of
mixed signals as set forth in claim 30, wherein the wherein the means for jointly
15 optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$
in an iterative manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and
a final estimated mixing matrix $\hat{\mathbf{A}}$ further comprises:

- i. means for obtaining a multi-band sparse domain estimate of the source signal
estimate matrix $\hat{\mathbf{S}}$ using the relationship $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$, applied in the Wavelet
20 domain; and
- ii. means for using the adjusted geometric constraint corresponding to the final
estimated mixing matrix $\hat{\mathbf{A}}$ in each of the bands of the Wavelet domain for the
source signal estimate matrix $\hat{\mathbf{S}}$, $\mathbf{W}(\hat{\mathbf{S}})$, and determining whether a
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$ is met for the source signal estimate
25 matrix $\hat{\mathbf{S}}$, where the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, is developed from
the log likelihood function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A})$ with the assumption of
Laplancity of source signals in the Wavelet domain following the probability

$$\mathbf{P}(\mathbf{W}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|}$$
, where $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit vector, and if the
convergence criteria is not met, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, iteratively adjusting the

5 clustering of the mixed signal samples to create a new set of clusters until the
convergence criteria, $\min \lambda c^T |W(\hat{S})|$, is met, to provide a final source signal
estimate matrix \hat{S} .

10 32. (Original) A computer program product for blind separation of an overcomplete set of
mixed signals as set forth in claim 30, wherein the computer program product is
configured for separating mixed acoustic signals.

15 33. (Original) A computer program product for blind separation of an overcomplete set of
mixed signals as set forth in claim 30, wherein the computer program product is
configured for separating mixed radio frequency signals.

34. (Cancelled)

20 35. (Currently Amended) ~~An apparatus for determining a CR bound for an estimated
mixing matrix \hat{A} developed in the blind separation of an overcomplete set of mixed
signals as set forth in claim 34;~~ An apparatus for determining a CR bound for an
estimated mixing matrix \hat{A} developed in the blind separation of an overcomplete set
of mixed signals, the apparatus comprising a data processing system including a
processor, a memory coupled with the processor, an input coupled with the processor,
25 an output coupled with the processor, means within the data processing system for
generating a CR bound for the estimated mixing matrix \hat{A} , and means for generating
an output of the expected value for the estimation error of associated lines of
correlation and for providing the output to a user via the output, whereby a CR bound
may be developed for determining the performance of an estimate of a mixing matrix
30 \hat{A} developed in the blind separation of an overcomplete set of mixed signals in order
that a user may know the performance limitations of a blind separation apparatus.

5 wherein the means for determining the expected value for the estimation error is in the form of $E\{\theta_i - \hat{\theta}_i\}^2$ where $E\{\theta_i - \hat{\theta}_i\}^2 \geq \frac{\lambda_k^2}{2N\mathbf{u}^T(\theta_i)\mathbf{p}^T\mathbf{R}_{w(v)}^{-1}\mathbf{p}\mathbf{u}(\theta_i)}$, where:

$E\{\theta_i - \hat{\theta}_i\}^2$ is an expected value for the estimation error of associated lines of correlation;

$\theta_i = \arctan\left(\frac{\mathbf{a}_i}{\|\mathbf{a}_i\|}\right)$, where $\mathbf{a}_i = \begin{bmatrix} a_{1i} \\ a_{2i} \end{bmatrix}$, $i = 1, 2, \dots, M$, and $\hat{\mathbf{A}} = \hat{\mathbf{A}}(\theta) = \mathbf{u}(\theta_i)$;

10 $\hat{\theta}_i$ is an estimated value corresponding to an actual value of θ_i ;

λ_k^2 is developed from the log likelihood function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A}(\theta))$ used for the estimation of the mixing matrix $\hat{\mathbf{A}}$ and the estimation of a source signal estimate matrix $\hat{\mathbf{S}}$;

N is a number of data samples used in the generation of the mixing matrix

15 $\hat{\mathbf{A}}$ and the source signal estimate matrix $\hat{\mathbf{S}}$;

$\mathbf{u}(\theta_i) = \begin{bmatrix} \cos(\theta_i) \\ \sin(\theta_i) \end{bmatrix}$;

$\mathbf{p} = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$;

T is the transpose operator; and

$\mathbf{R}_{w(v)}^{-1} = \begin{bmatrix} \sigma_{w(v)}^2 & \rho\sigma_{w(v)}^2 \\ \rho\sigma_{w(v)}^2 & \sigma_{w(v)}^2 \end{bmatrix}$, where $\sigma_{w(v)}^2$ is a cross correlation of a noise

20 set and ρ is a constant multiplier value.

36. (Cancelled).

37. (Currently Amended) ~~An apparatus for determining a CR bound for a source signal estimate matrix $\hat{\mathbf{S}}$ developed in the blind separation of an overcomplete set of mixed signals as set forth in claim 36, An apparatus for determining a CR bound for an~~
25 source signal estimate matrix $\hat{\mathbf{S}}$ developed in the blind separation of an overcomplete

5 set of mixed signals, the apparatus comprising a data processing system including a
processor, a memory coupled with the processor, an input coupled with the processor,
an output coupled with the processor, means within the data processing system for
generating a CR bound for the source signal estimate matrix $\hat{\mathbf{S}}$, and means for
generating an output of the expected value for the estimation error of associated lines
10 of correlation and for providing the output to a user via the output, whereby a CR
bound may be developed for determining the performance of an estimate of a source
signal estimate matrix $\hat{\mathbf{S}}$ developed in the blind separation of an overcomplete set of
mixed signals in order that a user may know the performance limitations of a blind
separation apparatus,

15 wherein the means for determining the expected value for the estimation error is in
the form of $E\{\mathbf{W}(\mathbf{S}) - \mathbf{W}(\hat{\mathbf{S}})\}^2$

where $E\{\mathbf{W}(\mathbf{S}) - \mathbf{W}(\hat{\mathbf{S}})\}^2 \geq \left(\sigma_v^2 \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \hat{\mathbf{A}}^T(\theta) \hat{\mathbf{A}}(\theta) + \lambda^2 \mathbf{I} \right)^{-1}$, where

σ_v^2 represents a noise level;

ρ is a constant multiplier value;

20 $\hat{\mathbf{A}}$ is an estimated mixing matrix;

$\theta_i = \arctan\left(\frac{\mathbf{a}_i}{\|\mathbf{a}_i\|}\right)$, where $\mathbf{a}_i = \begin{bmatrix} a_{1i} \\ a_{2i} \end{bmatrix}$, $i = 1, 2, \dots, M$, and $\hat{\mathbf{A}} = \hat{\mathbf{A}}(\theta) = \mathbf{u}(\theta_i)$;

λ_k^2 is developed from the log likelihood function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A}(\theta))$; and

\mathbf{I} is an identity matrix.

25 38. (Cancelled)

39. (Currently Amended) A method for determining a CR bound for an estimated mixing
matrix $\hat{\mathbf{A}}$ developed in the blind separation of an overcomplete set of mixed signals as
set forth in claim 38, A method for determining a CR bound for an estimated mixing
30 matrix $\hat{\mathbf{A}}$ developed in the blind separation of an overcomplete set of mixed signals,

5 operating on an apparatus comprising a data processing system including a processor,
a memory coupled with the processor, an input coupled with the processor, an output
coupled with the processor, the method comprising the steps of generating a CR
bound for the estimated mixing matrix $\hat{\mathbf{A}}$, and generating an output of the expected
value for the estimation error of associated lines of correlation and for providing the
10 output to a user via the output, whereby a CR bound may be developed for
determining the performance of an estimate of a mixing matrix $\hat{\mathbf{A}}$ developed in the
blind separation of an overcomplete set of mixed signals in order that a user may
know the performance limitations of a blind separation apparatus,
wherein in the step of determining the expected value for the estimation error, the
15 expected value for estimation error is in the form of $E\{\theta_i - \hat{\theta}_i\}^2$ where

$$E\{\theta_i - \hat{\theta}_i\}^2 \geq \frac{\lambda_k^2}{2N\mathbf{u}^T(\theta_i)\mathbf{p}^T\mathbf{R}_{w(v)}^{-1}\mathbf{p}\mathbf{u}(\theta_i)}, \text{ where:}$$

$E\{\theta_i - \hat{\theta}_i\}^2$ is an expected value for the estimation error of associated
lines of correlation;

$$\theta_i = \arctan\left(\frac{\mathbf{a}_i}{\|\mathbf{a}_i\|}\right), \text{ where } \mathbf{a}_i = \begin{bmatrix} a_{1i} \\ a_{2i} \end{bmatrix}, i = 1, 2, \dots, M, \text{ and } \hat{\mathbf{A}} = \hat{\mathbf{A}}(\theta) = \mathbf{u}(\theta_i);$$

20 $\hat{\theta}_i$ is an estimated value corresponding to an actual value of θ_i ;

λ_k^2 is developed from the log likelihood function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A}(\theta))$
used for the estimation of the mixing matrix $\hat{\mathbf{A}}$ and the estimation of a
source signal estimate matrix $\hat{\mathbf{S}}$;

N is a number of data samples used in the generation of the mixing matrix
25 $\hat{\mathbf{A}}$ and the source signal estimate matrix $\hat{\mathbf{S}}$;

$$\mathbf{u}(\theta_i) = \begin{bmatrix} \cos(\theta_i) \\ \sin(\theta_i) \end{bmatrix};$$

$$\mathbf{p} = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix};$$

5 T is the transpose operator; and

$$\mathbf{R}_{w(v)}^{-1} = \begin{bmatrix} \sigma_{w(v)}^2 & \rho \sigma_{w(v)}^2 \\ \rho \sigma_{w(v)}^2 & \sigma_{w(v)}^2 \end{bmatrix}, \text{ where } \sigma_{w(v)}^2 \text{ is a cross correlation of a noise}$$

set and ρ is a constant multiplier value.

40. (Cancelled).

10

41. (Currently Amended) ~~A method of determining a CR bound for a source signal~~

~~estimate matrix $\hat{\mathbf{S}}$ developed in the blind separation of an overcomplete set of mixed signals as set forth in claim 40; A method for determining a CR bound for an source~~

~~signal estimate matrix $\hat{\mathbf{S}}$ developed in the blind separation of an overcomplete set of~~

15

~~mixed signals, operated in an apparatus comprising a data processing system~~

~~including a processor, a memory coupled with the processor, an input coupled with~~

~~the processor, an output coupled with the processor, the method comprising the steps~~

~~of generating a CR bound for the source signal estimate matrix $\hat{\mathbf{S}}$, and generating an~~

~~output of the expected value for the estimation error of associated lines of correlation~~

20

~~and for providing the output to a user via the output, whereby a CR bound may be~~

~~developed for determining the performance of an estimate of a source signal estimate~~

~~matrix $\hat{\mathbf{S}}$ developed in the blind separation of an overcomplete set of mixed signals in~~

~~order that a user may know the performance limitations of a blind separation~~

~~apparatus,~~

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wherein the in the step of determining the expected value for the estimation error, the

expected value for the estimation error is in the form of $E\{\left(\mathbf{W}(\mathbf{S}) - \mathbf{W}(\hat{\mathbf{S}})\right)^2\}$

where $E\{\left(\mathbf{W}(\mathbf{S}) - \mathbf{W}(\hat{\mathbf{S}})\right)^2\} \geq \left(\sigma_v^2 \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \hat{\mathbf{A}}^T(\theta) \hat{\mathbf{A}}(\theta) + \lambda^2 \mathbf{I} \right)^{-1}$, where

σ_v^2 represents a noise level;

ρ is a constant multiplier value;

30

$\hat{\mathbf{A}}$ is an estimated mixing matrix;

5 $\theta_i = \arctan\left(\frac{\mathbf{a}_i}{\|\mathbf{a}_i\|}\right)$, where $\mathbf{a}_i = \begin{bmatrix} a_{1i} \\ a_{2i} \end{bmatrix}$, $i = 1, 2, \dots, M$, and $\hat{\mathbf{A}} = \hat{\mathbf{A}}(\theta) = \mathbf{u}(\theta_i)$;

λ_k^2 is developed from the log likelihood function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A}(\theta))$; and

\mathbf{I} is an identity matrix.

42. (Cancelled).

10

43. (Currently Amended) ~~A computer program product for determining a CR bound for an estimated mixing matrix $\hat{\mathbf{A}}$ developed in the blind separation of an overcomplete set of mixed signals as set forth in claim 42;~~ A computer program product for determining a CR bound for an estimated mixing matrix $\hat{\mathbf{A}}$ developed in the blind separation of an overcomplete set of mixed signals, the computer program product being written onto a medium readable on a data processing system including a processor, a memory coupled with the processor, an input coupled with the processor, an output coupled with the processor, with the computer program product comprising means for generating a CR bound for the estimated mixing matrix $\hat{\mathbf{A}}$, and means for generating an output of the expected value for the estimation error of associated lines of correlation and for providing the output to a user via the output, whereby a CR bound may be developed for determining the performance of an estimate of a mixing matrix $\hat{\mathbf{A}}$ developed in the blind separation of an overcomplete set of mixed signals in order that a user may know the performance limitations of a blind separation apparatus,

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20

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wherein the means for determining the expected value for the estimation error

determines an estimation error by calculating $E\{\theta_i - \hat{\theta}_i\}^2$ where

$$E\{\theta_i - \hat{\theta}_i\}^2 \geq \frac{\lambda_k^2}{2N\mathbf{u}^T(\theta_i)\mathbf{p}^T\mathbf{R}_{W(V)}^{-1}\mathbf{p}\mathbf{u}(\theta_i)}, \text{ where:}$$

$E\{\theta_i - \hat{\theta}_i\}^2$ is an expected value for the estimation error of associated

lines of correlation;

30

5 $\theta_i = \arctan\left(\frac{\mathbf{a}_i}{\|\mathbf{a}_i\|}\right)$, where $\mathbf{a}_i = \begin{bmatrix} a_{1i} \\ a_{2i} \end{bmatrix}$, $i = 1, 2, \dots, M$, and $\hat{\mathbf{A}} = \hat{\mathbf{A}}(\theta) = \mathbf{u}(\theta_i)$;

$\hat{\theta}_i$ is an estimated value corresponding to an actual value of θ_i ;

λ_k^2 is developed from the log likelihood function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A}(\theta))$ used for the estimation of the mixing matrix $\hat{\mathbf{A}}$ and the estimation of a source signal estimate matrix $\hat{\mathbf{S}}$;

10 N is a number of data samples used in the generation of the mixing matrix $\hat{\mathbf{A}}$ and the source signal estimate matrix $\hat{\mathbf{S}}$;

$$\mathbf{u}(\theta_i) = \begin{bmatrix} \cos(\theta_i) \\ \sin(\theta_i) \end{bmatrix};$$

$$\mathbf{P} = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix};$$

T is the transpose operator; and

15 $\mathbf{R}_{\mathbf{W}(\mathbf{V})}^{-1} = \begin{bmatrix} \sigma_{\mathbf{W}(\mathbf{V})}^2 & \rho\sigma_{\mathbf{W}(\mathbf{V})}^2 \\ \rho\sigma_{\mathbf{W}(\mathbf{V})}^2 & \sigma_{\mathbf{W}(\mathbf{V})}^2 \end{bmatrix}$, where $\sigma_{\mathbf{W}(\mathbf{V})}^2$ is a cross correlation of a noise set and ρ is a constant multiplier value.

44. (Cancelled).

20 45. (Currently Amended) ~~A computer program product for determining a CR bound for a source signal estimate matrix $\hat{\mathbf{S}}$ developed in the blind separation of an overcomplete set of mixed signals as set forth in claim 44, A computer program product for~~
determining a CR bound for an source signal estimate matrix $\hat{\mathbf{S}}$ developed in the blind separation of an overcomplete set of mixed signals, the computer program
25 product being written onto a medium readable on a data processing system including a processor, a memory coupled with the processor, an input coupled with the processor, an output coupled with the processor, with the computer program product comprising means for generating a CR bound for the source signal estimate matrix $\hat{\mathbf{S}}$.

5 and means for generating an output of the expected value for the estimation error of
associated lines of correlation and for providing the output to a user via the output,
whereby a CR bound may be developed for determining the performance of an
estimate of a source signal estimate matrix $\hat{\mathbf{S}}$ developed in the blind separation of an
overcomplete set of mixed signals in order that a user may know the performance
10 limitations of a blind separation apparatus,

wherein the means for determining the expected value for the estimation error

determines an estimation error by calculating $E\{\|\mathbf{W}(\mathbf{S}) - \mathbf{W}(\hat{\mathbf{S}})\|^2\}$

where $E\{\|\mathbf{W}(\mathbf{S}) - \mathbf{W}(\hat{\mathbf{S}})\|^2\} \geq \left(\sigma_v^2 \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \hat{\mathbf{A}}^T(\theta) \hat{\mathbf{A}}(\theta) + \lambda^2 \mathbf{I} \right)^{-1}$, where

σ_v^2 represents a noise level;

15 ρ is a constant multiplier value;

$\hat{\mathbf{A}}$ is an estimated mixing matrix;

$\theta_i = \arctan\left(\frac{\mathbf{a}_i}{\|\mathbf{a}_i\|}\right)$, where $\mathbf{a}_i = \begin{bmatrix} a_{1i} \\ a_{2i} \end{bmatrix}$, $i = 1, 2, \dots, M$, and $\hat{\mathbf{A}} = \hat{\mathbf{A}}(\theta) = \mathbf{u}(\theta_i)$;

λ_k^2 is developed from the log likelihood function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A}(\theta))$; and

\mathbf{I} is an identity matrix.

20

46. (New) An apparatus for blind separation of an overcomplete set of mixed signals as set forth in claim 5, wherein the means for generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$ comprises:

25

- i. means for transforming the mixed signal matrix \mathbf{X} into the frequency domain using a Fourier operator;
- ii. means for using a mutual information criterion to determine a frequency band within the sparse domain that contains the most information that can be used to determine lines of correlation to determine the number of signal sources;

5 iii. means for determining a random variable $ang = \arctan \frac{x_i(band)}{x_j(band)}$,

where $x_i(band)$ and $x_j(band)$ represent Fourier values of mixture in the selected frequency band, and an optimal threshold ANG for ang , where the optimal threshold ANG is determined by computing the entropy $E(ang, ANG)$ vs. ANG and searching for the optimal value of ANG corresponding to the minimum rate of descent of the entropy $E(ang, ANG)$;

iv. means for recalculating ang based on the optimal threshold ANG;

v. means for using a standard peak detection technique to determine the number and values of local maxima of a histogram of ang where the local maxima represent angles which are inserted into the estimated mixing matrix $\hat{\mathbf{A}}$ to provide an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$.

47. (New) An apparatus for blind separation of an overcomplete set of mixed signals as set forth in claim 46, wherein the means for jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$ comprises:

i. means for clustering the mixed signal samples in the Fourier domain along the lines of correlation with one cluster per source using a straight distance metric geometric constraint, with the clusters representing estimates of the Fourier domain representation of $\hat{\mathbf{S}}$, $\mathbf{F}(\hat{\mathbf{S}})$, where \mathbf{F} represents a Fourier domain operator ; and

ii. means for evaluating a convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, with the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, developed from the log likelihood function $L(\mathbf{F}(\hat{\mathbf{S}}) | \mathbf{F}(\mathbf{X}), \mathbf{A})$ with the assumption of Laplanicity of source signals in the

5 Fourier domain following the probability $P(\mathbf{F}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|}$, where

 $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit vector, with the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$,
evaluated based on the clustered mixed signal samples to determine whether the
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, and if the convergence criteria, \min
 $\lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is not met, iteratively adjusting the clustering of the mixed signal
10 samples and parameters of the geometric constraint to create a new set of
clusters until the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, to provide a final
estimated mixing matrix $\hat{\mathbf{A}}$.

48. (New) An apparatus for blind separation of an overcomplete set of mixed signals as
15 set forth in claim 47, wherein the means for jointly optimizing the source signal
estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to
generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing
matrix $\hat{\mathbf{A}}$ further comprises:
i. means for obtaining a multi-band sparse domain estimate of the source signal
20 estimate matrix $\hat{\mathbf{S}}$ using the relationship $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$, applied in the Wavelet
domain; and
ii. means for using the adjusted geometric constraint corresponding to the final
estimated mixing matrix $\hat{\mathbf{A}}$ in each of the bands of the Wavelet domain for the
source signal estimate matrix $\hat{\mathbf{S}}$, $\mathbf{W}(\hat{\mathbf{S}})$, and determining whether a
25 convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$ is met for the source signal estimate
matrix $\hat{\mathbf{S}}$, where the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, is developed from
the log likelihood function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A})$ with the assumption of
Laplancity of source signals in the Wavelet domain following the probability

5 $P(W(S)) = \frac{\lambda}{2} e^{-\lambda c^T |W(\hat{S})|}$, where $c^T = [1, 1, \dots, 1]$ is a unit vector, and if the

convergence criteria is not met, $\min \lambda c^T |W(\hat{S})|$, iteratively adjusting the
clustering of the mixed signal samples to create a new set of clusters until the
convergence criteria, $\min \lambda c^T |W(\hat{S})|$, is met, to provide a final source signal
estimate matrix \hat{S} .

10

49. (New) An apparatus for blind separation of an overcomplete set of mixed signals as
set forth in claim 48, wherein the apparatus is configured for separating mixed
acoustic signals.

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50. (New) An apparatus for blind separation of an overcomplete set of mixed signals as
set forth in claim 48, wherein the apparatus is configured for separating mixed radio
frequency signals.

20

51. (New) A method for blind separation of an overcomplete set of mixed signals as set
forth in claim 16, wherein the step of generating an initial estimate of the estimated
mixing matrix \hat{A} comprises the sub steps of:

25

- i. transforming the mixed signal matrix X into the frequency domain
using a Fourier operator;
- ii. using a mutual information criterion to determine a frequency band
within the sparse domain that contains the most information that can
be used to determine lines of correlation to determine the number of
signal sources;

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- iii. determining a random variable $ang = \arctan \frac{x_i(band)}{x_j(band)}$, where $x_i(band)$

and $x_j(band)$ represent Fourier values of mixture in the selected
frequency band, and an optimal threshold ANG for ang , where the
optimal threshold ANG is determined by computing the entropy

- 5 $E(ang, ANG)$ vs. ANG and searching for the optimal value of ANG corresponding to the minimum rate of descent of the entropy $E(ang, ANG)$;
- iv. recalculating ang based on the optimal threshold ANG ;
- v. using a standard peak detection technique to determine the number and
10 values of local maxima of a histogram of ang where the local maxima represent angles which are inserted into the estimated mixing matrix \hat{A} to provide an initial estimate of the estimated mixing matrix \hat{A} .

52. (New) A method for blind separation of an overcomplete set of mixed signals as set
15 forth in claim 51, wherein the step of jointly optimizing the source signal estimate matrix \hat{S} and the estimated mixing matrix \hat{A} in an iterative manner, to generate an optimized source signal estimate matrix \hat{S} and a final estimated mixing matrix \hat{A} comprises the sub steps of:
- i. clustering the mixed signal samples in the Fourier domain along the lines of
20 correlation with one cluster per source using a straight distance metric geometric constraint, with the clusters representing estimates of the Fourier domain representation of \hat{S} , $F(\hat{S})$, where F represents a Fourier domain operator ; and
- ii. evaluating a convergence criteria, $\min \lambda c^T |F(\hat{S})|$, with the convergence criteria,
25 $\min \lambda c^T |F(\hat{S})|$, developed from the log likelihood function $L(F(\hat{S}) | F(X), A)$ with the assumption of Laplanicity of source signals in the Fourier domain following the probability $P(F(S)) = \frac{\lambda}{2} e^{-\lambda c^T |F(\hat{S})|}$, where $c^T = [1, 1, \dots, 1]$ is a unit
vector, with the convergence criteria, $\min \lambda c^T |F(\hat{S})|$, evaluated based on the clustered mixed signal samples to determine whether the convergence criteria,
30 $\min \lambda c^T |F(\hat{S})|$, is met, and if the convergence criteria, $\min \lambda c^T |F(\hat{S})|$, is not met, iteratively adjusting the clustering of the mixed signal samples and

5 parameters of the geometric constraint to create a new set of clusters until the
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, to provide a final estimated mixing
matrix $\hat{\mathbf{A}}$.

53. (New) A method for blind separation of an overcomplete set of mixed signals as set
10 forth in claim 52, wherein the wherein the step of jointly optimizing the source signal
estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to
generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing
matrix $\hat{\mathbf{A}}$ further comprises the sub steps of:

- i. obtaining a multi-band sparse domain estimate of the source signal estimate
15 matrix $\hat{\mathbf{S}}$ using the relationship $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$, applied in the Wavelet domain;
and
- ii. using the adjusted geometric constraint corresponding to the final estimated
mixing matrix $\hat{\mathbf{A}}$ in each of the bands of the Wavelet domain for the source
signal estimate matrix $\hat{\mathbf{S}}$, $\mathbf{W}(\hat{\mathbf{S}})$, and determining whether a convergence
20 criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$ is met for the source signal estimate matrix $\hat{\mathbf{S}}$, where
the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, is developed from the log likelihood
function $\mathbf{L}(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A})$ with the assumption of Laplanicity of source
signals in the Wavelet domain following the probability $\mathbf{P}(\mathbf{W}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|}$,
where $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit vector, and if the convergence criteria is not met,
25 $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, iteratively adjusting the clustering of the mixed signal samples
to create a new set of clusters until the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, is
met, to provide a final source signal estimate matrix $\hat{\mathbf{S}}$.

- 5 54. (New) A method for blind separation of an overcomplete set of mixed signals as set forth in claim 53, wherein the method is configured to separate mixed acoustic signals.
- 10 55. (New) A method for blind separation of an overcomplete set of mixed signals as set forth in claim 53, wherein the method is configured to separate mixed radio frequency signals.
- 15 56. (New) A computer program product for blind separation of an overcomplete set of mixed signals as set forth in claim 27, wherein the means for generating an initial estimate of the estimated mixing matrix $\hat{\mathbf{A}}$ comprises:
- i. means for transforming the mixed signal matrix \mathbf{X} into the frequency domain using a Fourier operator;
 - ii. means for using a mutual information criterion to determine a frequency band within the sparse domain that contains the most information that can be used to determine lines of correlation to determine the number of signal sources;
 - 20 iii. means for determining a random variable $ang = \arctan \frac{x_i(band)}{x_j(band)}$,
where $x_i(band)$ and $x_j(band)$ represent Fourier values of mixture in the selected frequency band, and an optimal threshold ANG for ang ,
25 where the optimal threshold ANG is determined by computing the entropy $E(ang, ANG)$ vs. ANG and searching for the optimal value of ANG corresponding to the minimum rate of descent of the entropy $E(ang, ANG)$;
 - iv. means for recalculating ang based on the optimal threshold ANG;
 - 30 v. means for using a standard peak detection technique to determine the number and values of local maxima of a histogram of ang where the local maxima represent angles which are inserted into the estimated

5 mixing matrix $\hat{\mathbf{A}}$ to provide an initial estimate of the estimated mixing
matrix $\hat{\mathbf{A}}$.

57. (New) A computer program product for blind separation of an overcomplete set of
mixed signals as set forth in claim 56, wherein the means for jointly optimizing the
10 source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative
manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final
estimated mixing matrix $\hat{\mathbf{A}}$ comprises:

- i. means for clustering the mixed signal samples in the Fourier domain along the
lines of correlation with one cluster per source using a straight distance metric
15 geometric constraint, with the clusters representing estimates of the Fourier
domain representation of $\hat{\mathbf{S}}$, $\mathbf{F}(\hat{\mathbf{S}})$, where \mathbf{F} represents a Fourier domain
operator ; and
- ii. means for evaluating a convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, with the
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, developed from the log likelihood function
20 $\mathbf{L}(\mathbf{F}(\hat{\mathbf{S}}) | \mathbf{F}(\mathbf{X}), \mathbf{A})$ with the assumption of Laplanicity of source signals in the
Fourier domain following the probability $\mathbf{P}(\mathbf{F}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|}$, where
 $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit vector, with the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$,
evaluated based on the clustered mixed signal samples to determine whether the
convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, and if the convergence criteria, \min
25 $\lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is not met, iteratively adjusting the clustering of the mixed signal
samples and parameters of the geometric constraint to create a new set of
clusters until the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{F}(\hat{\mathbf{S}})|$, is met, to provide a final
estimated mixing matrix $\hat{\mathbf{A}}$.

5 58. (New) A computer program product for blind separation of an overcomplete set of mixed signals as set forth in claim 57, wherein the wherein the means for jointly optimizing the source signal estimate matrix $\hat{\mathbf{S}}$ and the estimated mixing matrix $\hat{\mathbf{A}}$ in an iterative manner, to generate an optimized source signal estimate matrix $\hat{\mathbf{S}}$ and a final estimated mixing matrix $\hat{\mathbf{A}}$ further comprises:

- 10 i. means for obtaining a multi-band sparse domain estimate of the source signal estimate matrix $\hat{\mathbf{S}}$ using the relationship $\mathbf{X} = \hat{\mathbf{A}}\hat{\mathbf{S}} + \mathbf{V}$, applied in the Wavelet domain; and
- ii. means for using the adjusted geometric constraint corresponding to the final estimated mixing matrix $\hat{\mathbf{A}}$ in each of the bands of the Wavelet domain for the source signal estimate matrix $\hat{\mathbf{S}}$, $\mathbf{W}(\hat{\mathbf{S}})$, and determining whether a
- 15 convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$ is met for the source signal estimate matrix $\hat{\mathbf{S}}$, where the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, is developed from the log likelihood function $L(\mathbf{W}(\hat{\mathbf{S}}) | \mathbf{W}(\mathbf{X}), \mathbf{A})$ with the assumption of Laplanicity of source signals in the Wavelet domain following the probability
- 20 $\mathbf{P}(\mathbf{W}(\mathbf{S})) = \frac{\lambda}{2} e^{-\lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|}$, where $\mathbf{c}^T = [1, 1, \dots, 1]$ is a unit vector, and if the convergence criteria is not met, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, iteratively adjusting the clustering of the mixed signal samples to create a new set of clusters until the convergence criteria, $\min \lambda \mathbf{c}^T |\mathbf{W}(\hat{\mathbf{S}})|$, is met, to provide a final source signal estimate matrix $\hat{\mathbf{S}}$.

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59. (New) A computer program product for blind separation of an overcomplete set of mixed signals as set forth in claim 57, wherein the computer program product is configured for separating mixed acoustic signals.

- 5 60. (New) A computer program product for blind separation of an overcomplete set of
mixed signals as set forth in claim 57, wherein the computer program product is
configured for separating mixed radio frequency signals

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